Accelerator Physics Experiments for Future Hadron Colliders

EXPERIMENTS IN RHIC (summer 2000 ??):

Beam Growth Studies with Primary and Bent Crystal Collimators

- **Introduction**
- **Previous Experience**
- **Predictions for the Intrabeam Scattering**
- **Bent Crystal Channeling**
- **Experimental Set-Up**

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Introduction:

- Motivation for the experiment:
  - Show that ***intrabeam scattering*** is a dominant effect on the beam life time and on the emittance growth in RHIC $_{197}$Au $^{79+}$ (important also in the future LARGE Hadron colliders).
  - Experimentally find out the exact scale of the problem. Why?
    - Find the optimum mode for operation!
    - Plan a correct way for the luminosity upgrade - RD projects - what kind?
  - Connect the experiment with luminosity optimization and Background reduction.
  - Use the impact parameter measurements to show the way of beam growth:
    - First by using the Primary Collimator jaws
    - Second with the CRYSTAL collimation.

Previous Experience:

- Major "rules":
  - Measure a signal downstream of the collimation point without reducing the luminosity
  - Fit a response curve to the predicted beam growth (Intrabeam scattering?, Diffusion?)
- SPS measurements (LHC note 117):
  - Measurements of the transverse difusion speed and the impact parameter-b
- Difusion and 778 experiments in the Tevatron
- HERA measurements (Bruning et al.)

Intra Beam Scattering Predictions:

- INTRA-BEAM multiple Coulomb scattering has cross section:
  - $\sigma \cong Z^4/A^2$
- Particles in the bunch exchange longitudinal and transverse momenta by Coulomb scattering
- D.C background, beam halo, or trapped particles in the empty buckets, could be created by the escaped particles from the RF bucket (initial bucket area of ~0.3 eVs/u -> ~1.3 eVs/u).
- COMPARISONS BETWEEN EXPERIMENTAL STUDIES with THEORY show a factor of two over-estimate by theory.
- Beam Growth at $\gamma >> \gamma_t$:
  - $1/\sigma_x \, d\sigma_x/dt = Z^4 N C_o/(A^2 \varepsilon_x \varepsilon_y S \gamma_t) \, d/n_c$
  - $\tau^{-1} \sim Z^4 N /(A^2 \varepsilon_x \varepsilon_y S)$

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Measurement of the impact parameter *b:*

- Measurements of the impact parameter ***b*** by using the edge of the primary collimator or:
- Using a bent Si crystal (L=5 mm) (Valery Biryukov Phys. Rev. E 52 (1995) 2045). One looks at the efficiency ***F*** dependence on ***t*** (thickness of the septum x'L):
  - Accuracy $\delta b = \delta x' * L = 1\ \mu rad\ 5\ mm = 5\ nm$! If we plot $F(x') - F(-x')$ as a function of t beam distribution over the impact parameter b at crystal (BPM resolution 0.1 mm).
  - $\theta = 0$, $t = x'L$ $(x'>0)$, $t = x'L$ $(x'<0)$

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Why Bent Crystal Collimation?

- The Lindhard Critical angle significantly larger (8.9 times - $79^{1/2}$) :
  - $\psi_c = 2[Z_1 Z_2 e^2/d\ p\ \upsilon]^{1/2}$, where ***d*** - is the crystal lattice parameter, p - momentum, υ is the speed.
- Shorter Crystal (5 mm instead of 4 cm) improves efficiency and reduces the nuclear scattering beam loss
- Smaller bending angle (0.5 mrad) reduces angle problems (4-5 mrad previously)

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